Endothermic and   
Exothermic Reactions

Background Info

Many chemical reactions give off energy. Chemical reactions that release energy are called *exothermic* reactions. Some chemical reactions absorb energy and are called *endothermic* reactions. You will study one exothermic and one endothermic reaction in this experiment.

In Part I, you will study the reaction between citric acid solution and baking soda. An equation for the reaction is:

H3C6H5O7(aq) + 3 NaHCO3(s) 3 CO2(g) + 3 H2O(aq) + Na3C6H5O7(aq)

In Part II, you will study the reaction between magnesium metal and hydrochloric acid. An equation for this reaction is:

Mg(s) + 2 HCl(aq) H2(g) + MgCl2(aq)

Another objective of this experiment is for you to become familiar with using the DataMate   
data-collection program on the TI Graphing Calculator. In this experiment, you will use the program to collect and display data as a graph or list, to examine your experimental data values on a graph, and to print graphs and data lists.



Figure 1

MATERIALS

|  |  |
| --- | --- |
| LabPro or CBL 2 interface | Styrofoam cup |
| TI Graphing Calculator | 250-mL baker |
| DataMate program | citric acid, H3C6H5O7, solution |
| Temperature Probe | baking soda, NaHCO3 |
| 50-mL graduated cylinder | hydrochloric acid, HCl, solution |
| balance | magnesium, Mg |

PROCEDURE

1. Obtain and wear goggles.

Part I Citric Acid plus Baking Soda

2. Plug the Temperature Probe into Channel 1 of the LabPro. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

3. Place a Styrofoam cup into a 250-mL beaker as shown in Figure 1. Measure out 30 mL of citric acid solution into the Styrofoam cup. Place the Temperature Probe into the citric acid solution.

4. Weigh out 10.0 g of solid baking soda on a piece of weighing paper.

5. Turn on the calculator and follow these steps to start the DATAMATE program.

TI-83 Plus Calculators:

Press , then press the calculator key for the *number* that precedes the DATAMATE program. You are now at the main screen of the program. Press  to reset the program.

6. Set up the calculator and interface for the Temperature Probe.

1. Select SETUP from the main screen.
2. If the calculator displays a Temperature Probe in CH 1, proceed directly to Step 7. If it does not, continue with this step to set up your sensor manually.
3. Press  to select CH 1.
4. Select TEMPERATURE from the SELECT SENSOR menu.
5. Select the Temperature Probe you are using (in °C) from the TEMPERATURE menu.

7. Set up the data-collection mode.

1. To select MODE, press  once and press .
2. Select TIME GRAPH from the SELECT MODE menu.
3. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
4. Enter “3” as the time between samples in seconds.
5. Enter “50” as the number of samples. The length of the data collection will be 2.5 minutes.
6. Select OK to return to the setup screen.
7. Select OK again to return to the main screen.

8. You are now ready to begin collecting data.

1. Select START on the main screen.
2. After about 20 seconds have elapsed, add the baking soda to the citric acid solution. Gently stir the solution with the Temperature Probe to ensure good mixing.
3. A real-time graph of temperature *vs.* time will be displayed on the calculator screen during data collection.
4. Temperature readings (in °C) can also be monitored in the upper-right corner of the graph.
5. Data collection will stop after 5 minutes, and a graph of temperature *vs.* time will be displayed.

9. Rinse out cup with a lot of water in the sink. Wash cup with soap and paper towel. Dry and reuse for next experiment. Wash all glassware in the same way, except use steel wool. Rinse and dry temp probe (steel end only).

10. Use the  or  keys to examine the data points along the displayed curve of temperature *vs.* time. Write down each set of points on your chart. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed below the graph. Determine the initial temperature, t1, and final (or minimum) temperature, t2. Record the temperature values in your data table (round to the nearest 0.1°C).

11. Store the data from the first run so that it can be used later. To do this:

1. Press  to return to the main screen, then select TOOLS.
2. Select STORE LATEST RUN from the TOOLS MENU.

Part II Hydrochloric Acid Plus Magnesium

12. Measure out 30 mL of HCl solution into the Styrofoam cup. Place the Temperature Probe into the HCl solution. Note: The Temperature Probe must be in the HCl solution for at least 30 seconds before doing Step 15.

13. Get the magnesium and scoopula ready.

14. Choose START on the main screen to begin data collection. After about 20 seconds have elapsed, CAREFULLY add a scoop (approx 3 cm in length) of the Mg to the HCl solution. **Caution:** Keep hand from passing over cup. Gently stir the solution with the Temperature Probe to ensure good mixing. **Caution:** Do not breathe the vapors. Data collection will stop after 5 minutes.

15. Dispose of the reaction products as before. Rinse the Temperature Probe.

16. Examine the data points along the displayed curve of temperature *vs.* time. Write down each set of points on your chart. Determine the initial temperature, t1, and the final (or maximum) temperature, t2. Record the temperature values in your data table (round to the nearest 0.1°C).

17. Tomorrow in class you will construct a graph in your data section which includes both graphs.

- Each graph line should be a different color

- Start in pencil, go over in colored pencil (No Pen!)

- Include a legend, and labels for each variable

- Independent variable goes on the x-axis (time) Dependent on the y-axis (temp)

- Use an entire sheet of graph paper.

- Don’t forget your conclusion at the end

18. Optional (You can also examine the data by viewing the data lists directly. To do this, press  to return to the main screen, and select QUIT. (Also press  on a TI-83 Plus or TI-73). Then follow this procedure for your calculator:

TI-73, TI-83, and TI-83 Plus Calculators

To view the lists, press  to display the EDIT menu and then select Edit. Press  to scroll down through the data lists L1 (time) and L2 (temperature) for Part II. **Note:** When you choose to repeat a data collection, as you did in Step 11 of this experiment, the temperature data in L2 of the first data run will be stored in L3. You can view the data for Part I of the experiment in L1 and L3.) – *Another way of looking at the data set*

19. Optional (A good way to compare the two curves is to view both sets of data on one graph.

1. Turn on the calculator and start the DATAMATE program.
2. Select GRAPH from the main screen, then press .
3. Select MORE, then select L2 AND L3 VS L1 from the MORE GRAPHS menu.
4. Both temperature runs should now be displayed on the same graph. Each point of Part I (citric acid and baking soda) is plotted with a box, and each point of Part II (hydrochloric acid and magnesium) is plotted with a dot.) – *to view both graphs at once*

DATA TABLE

Make chart 1 (include a line for every 3 seconds! – 52 rows)

|  |  |  |
| --- | --- | --- |
| time | temp trial 1 | temp trial 2 |
| 0 |  |  |
| 3 sec |  |  |
| 2 min 30 sec |  |  |

|  |  |  |
| --- | --- | --- |
|  | Part I | Part II |
| Final temperature, t2 | °C | °C |
| Initial temperature, t1 | °C | °C |
| Temperature change, t | °C | °C |

Processing the data

1. Calculate the temperature change, t, for each reaction by subtracting the initial temperature, t1, from the final temperature, t2 (t = t2 – t1).

2. Tell which reaction is exothermic. Explain.

3. Which reaction had a negative t value? Is the reaction endothermic or exothermic? Explain.

4. For each reaction, describe three ways you could tell a chemical reaction was taking place.

5. Which reaction took place at a greater rate? Explain your answer.